

**EUROPEAN PATENT APPLICATION**

Application number: 90104466.9

Int. Cl.<sup>5</sup>: **F16H 25/20**

Date of filing: **08.03.90**

Priority: **09.03.89 IT 6716289**

**I-10143 Torino(IT)**

Date of publication of application:  
**12.09.90 Bulletin 90/37**

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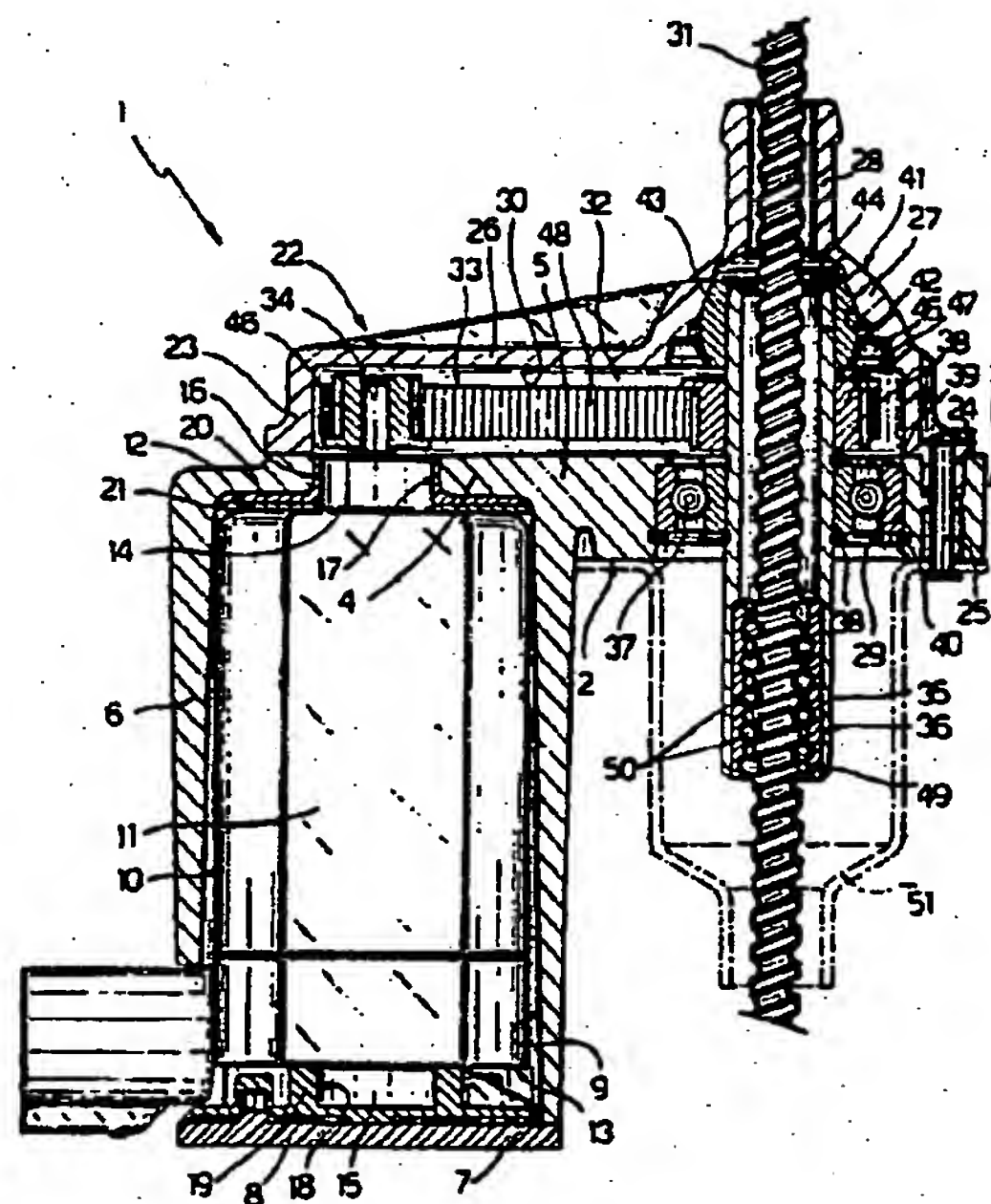
Designated Contracting States:  
**DE ES FR GB IT**

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**Electromechanical linear actuator.**

A linear actuator (1) wherein a load-bearing body or structure (2) made of relatively heavy metal provides for flexibly supporting an electric motor (10), the output shaft (34) of which is connected, via a belt drive (33), to a tubular shaft (35) parallel to the output shaft (34) of the motor (10), and connected in rotary manner, at a first point, to the load-bearing structure (2) and, at a second point, to a plastic element (22) integral with the load-bearing structure; the output member of the actuator (1) consisting of a screw (31) coaxial with the tubular shaft (35) and connected to the same via a recirculating-ball screw-nut-screw coupling (36).



## ELECTROMECHANICAL LINEAR ACTUATOR

The present invention relates to an electromechanical linear actuator.

In particular, the present invention relates to an electromechanical linear actuator comprising an electric motor with a rotary output shaft, and a straight-line output member.

Linear actuators of the aforementioned type are known to comprise an electric motor with a hollow shaft, designed to impart reciprocating straight-line motion to an output rod extending coaxially through the hollow shaft and connected to the same via a screw-nut-screw coupling.

Though perfectly functional in most respects, known linear actuators of the aforementioned type present a number of both economic and functional drawbacks, due to the hollow-shaft electric motors employed, which are invariably more cumbersome and expensive than the equivalent solid-shaft types.

A known method of overcoming the above drawbacks is to employ a standard solid-shaft motor on which the hollow shaft is located externally using a tubular shaft parallel to the output shaft of the motor and connected to the same via any type of parallel rotary shaft drive. Though relatively straightforward in terms of design, the above solution is extremely difficult to actually implement for achieving an actuator with a relatively high degree of precision and long working life.

Long working life of the actuator, in fact, is usually only obtainable by providing for relatively rigid support of the driven tubular shaft, so as to ensure substantially perfect parallelism between the tubular shaft and the output shaft of the motor. Such a solution, however, invariably results in the vibration produced by the motor being transmitted to the driven tubular shaft, and in impaired performance of the screw-nut-screw coupling.

The aim of the present invention is to provide a linear actuator designed to enable employment of a standard solid-shaft electric motor, while at the same time providing for relatively low-cost production, high operating precision and long working life.

With this aim in view, according to the present invention, there is provided an electromechanical linear actuator comprising an electric motor with a rotary output shaft; a load-bearing structure defining a housing for said electric motor; a tubular shaft substantially parallel to said output shaft and having a first portion connected in rotary manner to said load-bearing structure; an output member coaxial with said tubular shaft; a parallel rotary shaft drive located between said tubular and said output shafts; and a screw-nut-screw coupling located between said tubular shaft and said output member;

characterised by the fact that it also comprises a supporting member integral with said load-bearing structure and having means for connection in rotary manner to a second portion of said tubular shaft; said load-bearing structure being made of relatively heavy material; said drive comprising a flexible drive member; and damping means being provided between said motor and said housing.

The invention will be described with reference to the accompanying drawing showing an axial section of a preferred non-limiting embodiment of the same.

Number 1 in the accompanying drawing indicates an electromechanical linear actuator comprising a load-bearing body or structure 2 preferably formed from aluminium alloy or similar metal of relatively high specific weight.

Body 2 comprises a substantially rectangular plate 3 having a substantially circular end portion 4 thinner than the remaining portion 5 of plate 3 and constituting the end wall of a substantially cylindrical cup-shaped body 6 integral with plate 3 and having, on the opposite side to portion or wall 4, an opening 7 closed by a circular plate 8 of plastic material.

Body 6 defines a cylindrical chamber 9 housing a d.c. electric motor 10 with a substantially cylindrical outer casing 11. From the opposite surfaces 12 and 13 of casing 11, there project outwards respective cylindrical axial appendixes 14 and 15.

Via the interposition of a plastic sleeve 16, appendix 14 engages a hole 17 formed through wall 4, whereas appendix 15 engages a cylindrical compartment 18 formed centrally on a flexible cover 19 connected integral with the inner surface of plate 8.

From the end of sleeve 16 facing inwards of chamber 9, there extends outwards an annular flange 20 arranged contacting the inner surface of wall 4 on one side and, on the other, surface 12 of casing 11 via the interposition of a flexible annular seal 21.

On the opposite side to that supporting body 6, plate 3 is fitted with a cup-shaped body 22 comprising a lateral wall 23, one end of which is fitted with an outer flange 24 connected integral with plate 3 by means of through pins 25 (only one of which is shown), and the other end of which is fitted with an end wall 26. From the portion of wall 26 facing portion 5 of plate 3, there projects outwards a substantially semispherical dome 27 having a tubular radial outer appendix 28 perpendicular to plate 3 and coaxial with a further hole 29 formed through portion 5.

Body 22 is preferably made of plastic and, together with plate 3, defines a chamber 30 fitted through with a screw 31 coaxial with appendix 28 and hole 29, and connected to motor 10 via a drive indicated as a whole by 32, so as to move axially in a direction perpendicular to plate 3.

Drive 32 is housed inside chamber 30, and comprises a belt drive 33 between rotary output shaft 34 of motor 10 and a rotary tubular shaft 35 extending through hole 29 and coaxial with screw 31; and a recirculating-ball screw-nut-screw coupling 36 located between shaft 35 and screw 31.

Shaft 35 is supported by plate 3 via the interposition of a ball bearing 37, the inner ring of which is secured axially to the outer surface of an intermediate portion of shaft 35 via two retaining rings 38, and the outer ring of which is locked inside hole 29 by a shoulder 39 on one side and by a retaining ring 40 on the other. One end of shaft 35 is supported by wall 26 via a spherical joint 41 comprising a semispherical seat 42 formed inside dome 27; and a spherical head defined by a bush 43, a cylindrical through hole 44 of which is engaged in rotary manner by shaft 35, and the substantially spherical outer surface of which is maintained contacting seat 42 by a lock washer 45.

Drive 33 comprises two toothed pulleys 46 and 47 fitted respectively on to shaft 34 and on to shaft 35 in the space between bearing 37 and bush 43. Drive 33 also comprises a toothed belt 48 looped about pulleys 46 and 47, and extending parallel with plate 3 inside chamber 30. Coupling 36 is of known type, comprising a relatively lightweight nut screw 49 preferably formed from rolled sheet metal. Nut screw 49 is integral and coaxial with shaft 35, and connected to screw 31 via the interposition of a number of spheres 50.

Coupling 36 is preferably protected by a cover 51 (shown by the dotted line) connected to plate 3 by means of pins 25.

The first point to note in connection with the above description is the manner in which electric motor 10 is supported flexibly inside chamber 9, by virtue of the opposed elastic elements consisting of seal 21 on the one hand and cover 19 on the other, which provide for flexible axial suspension of motor 10. Moreover, by flexibly supporting appendix 15 of casing 11 inside compartment 18, cover 19 also provides for radial suspension of motor 10 and for preventing casing 11 of the same from vibrating in contact with cylindrical body 6.

In other words, therefore, by virtue of being flexibly suspended inside chamber 9, the vibration transmitted to plate 3 by motor 10 is of practically negligible frequency and amplitude, which vibration is further dampened by the weight of plate 3 itself. Moreover, belt 48 and plastic body 22 substantially eliminate any danger of the vibration produced by

motor 10 being transmitted directly to nut screw 49 via drive 33 and joint 41.

It follows therefore that, despite being relatively lightweight, nut screw 49 is extremely stable in use, by virtue of being affected only negligibly by the vibration of motor 10, and is maintained perfectly parallel to shaft 34 by the two supports, consisting of bearing 37 and joint 41, connected to shaft 35 on opposite sides of pulley 47.

## Claims

1) - An electromechanical linear actuator (1) comprising an electric motor (10) with a rotary output shaft (34); a load-bearing structure (3) defining a housing (9) for said electric motor (10); a tubular shaft (35) substantially parallel to said output shaft (34) and having a first portion connected in rotary manner to said load-bearing structure (3); an output member (31) coaxial with said tubular shaft (35); a parallel rotary shaft drive (33) located between said tubular (35) and said output (34) shafts; and a screw-nut-screw coupling (36) located between said tubular shaft (35) and said output member (31); characterised by the fact that it also comprises a supporting member (22) integral with said load-bearing structure (3) and having means for connection in rotary manner to a second portion of said tubular shaft (35); said load-bearing structure (3) being made of relatively heavy material; said drive (33) comprising a flexible drive member; and damping means (19, 21) being provided between said motor (10) and said housing (9).

2) - An actuator as claimed in Claim 1, characterised by the fact that said flexible drive member is connected to said tubular shaft (35) between said first and second portions of the same.

3) - An actuator as claimed in Claim 1 or 2, characterised by the fact that said supporting member (22) is made of plastic.

4) - An actuator as claimed in Claim 1, 2 or 3, characterised by the fact that said rotary connecting means comprise a spherical joint (41).

5) - An actuator as claimed in Claim 4, characterised by the fact that said rotary connecting means comprise a bush (43) having an inner surface connected in rotary manner to said tubular shaft (35), and a spherical outer surface; said spherical joint (41) comprising a seat (42) formed on said supporting member (22), and a spherical head mating with said seat (42) and defined by said bush (43).

6) - An actuator as claimed in any one of the foregoing Claims, characterised by the fact that said housing (9) is defined by a hollow elongated body (6) closed at one end by an end wall (4) and at the other end by a cover (8); said damping

means comprising first and second opposed flexible elements (21, 19) located between the casing (11) of said motor (10) and said bottom wall (4) and said cover (8) respectively.

7) - An actuator as claimed in Claim 6, characterised by the fact that said casing (11) presents an axial end appendix (15) extending towards said cover (8); said second flexible element (19) consisting of a cover having an axial compartment (18) engaged by said appendix (15).

8) - An actuator as claimed in any one of the foregoing Claims, characterised by the fact that said screw-nut-screw coupling (36) is a recirculating-ball screw-nut-screw coupling.

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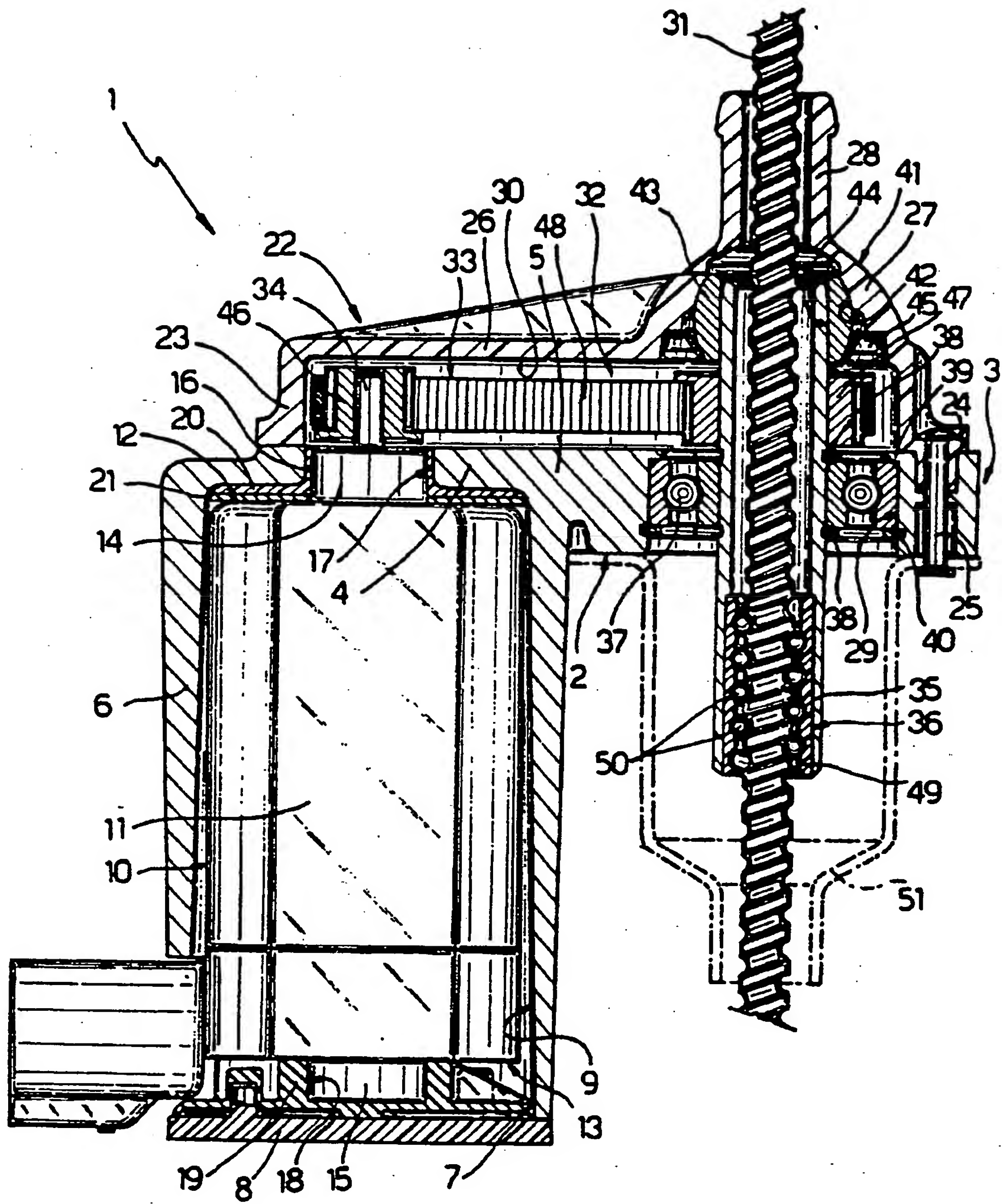
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## EUROPEAN SEARCH REPORT

Application Number

EP 90 10 4466

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-4583421 (MARVIN D. ROSE) * abstract * * column 2, lines 3 - 11; claims 1, 9, 10, 12; figures 1-4 *	1, 2, 6	F16H25/20
A	EP-A-253735 (AUTOMOBILES PEUGEOT) * abstract; claims 1, 7; figure *	1, 2, 8	
A	FR-A-1287937 (LICENTIA PATENT VERWALTUNG G.M.B.H.) * the whole document *	1, 6, 7	
A	GB-A-2078903 (ROCKWELL INTERNATIONAL CORP.) * abstract; figures 1-3 *	4, 5	
A	US-A-2649300 (JAMES MARK LAUNDER) * claim 4; figure 5 *	1	
A	US-A-4841790 (GENERAL MOTORS CORP.) * abstract; figure *	1, 8	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F16H B62D F16F H02K
Place of search THE HAGUE		Date of completion of the search 13 JUNE 1990	Examiner VINGERHOETS A.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons A : member of the same patent family, corresponding document			